DIVISION 16 – ELECTRICAL

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes requirements for basic electrical materials and methods. It includes requirements for the following listed materials:

1. Power, control and instrument conductors.
2. Rigid, PVC, flexible and liquid tight raceways and fittings.
3. Wire nuts.
4. Bolted and pressure connectors.
5. Terminal blocks.
6. Device, pull and junction boxes and covers.
7. Cabinets.
8. Wireways.
9. Building wire and connectors.
10. Supporting devices for electrical components.
11. Electrical identification.
12. Concrete equipment bases.
13. Cutting and patching for electrical construction.
14. Touch-up painting.

B. This Section applies to all sections of Division 16 and to other sections that include electrical equipment requirements except when in these individual sections requirements are otherwise specified. Electrical systems shall be complete including all miscellaneous materials, and be ready for operation as indicated in accordance with the Contract Documents. Leachate pump vaults shall be classified as Class 1, Division I, Group D locations. The valve and meter vaults shall be wet label locations.

1.2 QUALITY ASSURANCE

A. Electrical work shall be performed and all materials shall be in accordance with the National Electrical Code. Above code shall be minimum requirements for electrical work and if there is a conflict between the requirements specified in the Contract Documents and the code, the more stringent will apply as determined and approved by the Engineer.

B. Unless otherwise indicated, provide electrical materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design that conforms to these Specifications. When two or more units of the same class of material and equipment are required, these units shall be the products of the same manufacturer.

C. Electrical Oversight: Provide a Master Electrician to oversee electrical installation of Journeyman's work. Note: Electrician shall be on –site, no less than 10 hours per week.

1.3 JOB CONDITIONS

A. The Drawings indicate the extent and general arrangement of the principal electrical elements, outlets and circuit layouts. It is the intent that all electrical elements and devices provided under this and other sections be properly connected and interconnected to form a workable system as required by the Contract Documents whether the connections and interconnections are specifically stated in the Specification or shown on the Drawings. Additional circuits shall be installed wherever required to conform to the specific requirements of the furnished equipment and for proper installation of the work without additional cost.

1.4 IDENTIFICATION FOR SYSTEM AND EQUIPMENT 600 VOLTS AND LESS

A. General

1. Identify and label each conductor.
2. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
3. Color-Coding Cable Ties: Type 6/6 nylon, self-locking type. Colors to suit coding scheme.

B. Conductor Identification

1. Power conductors terminating in panelboards, cabinets, motor control centers and special service outlets shall be identified at each end and in intervening junction and pull boxes. Where feeder conductors pass through a common box, tag the feeder to indicate the circuit number and panelboard designation. Labels shall be located near the conductor ends for terminals and on exposed portions of conductor within pull and junction boxes.

2. Control wiring shall be identified at each end of each wire by a number conforming with the following:

Wiring for Pump No. 1 shall be labeled with numbers from 100 to 199. Wiring for Pump No. 2 shall be labeled with numbers from 200 to 299, and so forth. Wiring for

auxiliary equipment shall use wire numbers not used for the pumping units. Where it is impractical to maintain the same wire numbers throughout, a terminal block shall be installed at the junction of the different numbered wires. On each side of the terminal block each associated wire number shall be typed or written in with permanent ink.

3. Labels shall be plastic slip-on ferrule type with durable machine printed letters, numerals and other identifying characters.

PART 2 - MATERIAL

2.1 RACEWAY AND FITTINGS

A. General

1. Minimum size shall be 3/4 inch except where ½ inch is indicated.
2. Fittings shall be of the same material and match the raceway.

B. Raceways

1. Rigid steel, heavy wall, hot-dip galvanized meeting requirements of UL-6 and ANSI C80.1.

2. Intermediate Metal Conduit and fittings: ANSI C80.6.

3. Rigid non-metallic conduit shall be Schedule 80 PVC meeting requirements of UL-651 with solvent cement joints.

4. Liquid-tight flexible shall be single strip steel, hot- dip galvanized with PVC jacket meeting requirements of UL-360. Conduit sizes 1-1/4 inch and smaller shall include a continuous copper bonding conductor wound spirally between convolutions on the inside of the conduit.

5. PVC coated rigid steel shall meet the requirements for rigid steel raceway herein and have 40 mils bonded PVC jacket meeting requirements of NEMA RN-1 type A-40. PVC coated conduit shall have a minimum of 2-mil urethane interior coating.

C. Fittings

1. Fittings shall be of the same material and finish as the raceways and shall meet requirements of UL-514 and ANSI C80.4. Threaded connectors shall be used for all rigid metal conduits.

2. For enclosures, cabinets and boxes in dry areas use nylon insulated bushing and lock-nut.

3. For enclosures, cabinets and boxes in wet areas use watertight hub fitting with gasket.

4. Connectors for liquid-tight flexible conduit shall have factory installed liner of plastic in areas of contact with conductor insulation. Neoprene sealing rings shall be provided when conduit is installed in knockout.

D. Miscellaneous Specialty Fittings

1. For exterior walls, roof and where watertightness is required, provide watertight sealing sleeves for raceway penetrations consisting of a steel sleeve with pressure ring and clamps or an assembly of molded rubber links with pressure plates and through bolts which may be tightened at any time. Seal between raceway and concrete shall withstand 25 feet of water head without leaking.

2. For interior walls, floors and where watertightness is not required provide schedule 40 galvanized steel pipe sleeves and plastic expandable sealant.

4. Provide raceway expansion fittings where raceway crosses building or concrete expansion joints. Provide bonding jumper with each expansion fitting.

2.2 METAL WIREWAYS

A. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1, 3R, 12, or 4 as required for the application.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

D. Wireway Covers: Hinged type, Screw-cover type Flanged-and-gasketed type as required for the application.

E. Finish: Manufacturer's standard enamel finish.

2.3 RACEWAY SUPPORTS

A. Support raceway at intervals and at locations as required by the NEC. Do not use perforated straps or plumbers tape for conduit supports. Independently support raceways from the

structure except as may be directed by the Engineer. Supports and hangers shall be steel, hot dip galvanized after fabrication except P.V.C. coated or stainless steel supports shall be provided for P.V.C. or coated raceways.

B. Fasteners for concrete shall be expansion bolts or inserts, toggle bolts for hollow masonry or frame construction and preset inserts for prestressed concrete. Anchors in wet or damp locations shall be stainless steel.

C. For raceways supported on surface, provide straps with holes for one or two fasteners and shaped to fit raceway size.

D. At structural steel members support raceway with hot dip galvanized beam clamps. Drilling or welding may be used only where indicated on the Drawings or as approved by the Engineer.

E. For suspended raceways, provide galvanized hanger rods not less than 3/8 inch diameter for raceways up to 2- inch diameter and 1/2 inch diameter rods for raceways larger than 2-inch diameter. Rods shall be threaded a minimum of 1-1/2 inches on each end to permit adjustment. Rods shall be stainless steel or hot dipped galvanized.

F. For multiple suspended raceways, the horizontal channel shall not be less than 1-1/2 inches squire by 12 gauge. Weld two or more together when greater strength is required to limit deflection to 1/2000 of span. Hanger for the horizontal channel shall be sized for the number and size of raceways supported as shown on the drawings or if not shown as directed by the Engineer.

G. Exposed raceways on walls below grade, in damp, wet or corrosive locations shall be installed with standoff brackets providing a minimum of 1/4 inch air space between the raceway and the mounting surface.

H. All supports, hangers, preformed channels and clamps shall be type 304 stainless steel or P.V.C. coated. Bolts and nuts shall be type 304 stainless steel.

I. Where raceway may be affected by dissimilar movements of the supporting structures or medium, provide flexible or expansion devices.

J. Provide minimum 2" of backfill on bottom of trenches to support all power and signal conduits.

2.4 WIRE AND CABLE - 600 VOLTS AND BELOW

A. General

1. Conductors shall be copper, 98 percent conductivity, soft annealed copper meeting

requirements of ASTM B33. No. 12 and No. 10 AWG shall be solid, and No. 8 AWG and larger gauge stranded.

2. Minimum conductor sizes shall be as follows:

   a. Power and lighting branch circuits No. 12 AWG except where indicated.
   b. 120 volt control circuits, No. 14 AWG, stranded.
   c. Low energy control and signal circuits as indicated on Drawings.

3. Voltage Drop: Provide all conductor sizes as required to accommodate voltage drop. Overall VD shall not exceed 3% on any branch circuit.

B. Insulation

1. Unless otherwise indicated, wire and cable shall be insulation type THWN, THHN or XHHW.

C. Identification

1. Wire cable shall have following information surface printed at regular intervals throughout the entire length.

   a. Manufacture or trade name.
   b. Size of conductor.
   c. Type of insulation
   d. Voltage classification

D. Color Coding

1. Color coding shall be provided throughout the entire network for service, feeder, branch, control and low energy signal circuit conductors. Color coding of conductors 10 AWG and smaller shall have factory impregnated color throughout its entire length. Conductors No. 8 AWG and larger gauge may be marked with color coding tape a minimum of 0.004 inch in thickness. Color shall be green for grounding conductors, and white or gray for neutrals. The color of conductors for different voltage systems shall be as follows (Voltages are as applicable):

SYSTEM	PHASE A	PHASE B	PHASE C	NEUTRAL	GROUND
208/120 three phase	black	red	blue	white	green
480/277					

three phase	yellow	brown	orange	gray	green
240/120	black	red	orange (high leg)	white	green
Control and low-energy signal	red	---	---	white	green

2.5 WIRE CONNECTIONS AND CONNECTING DEVICES

A. Splice and Termination Components

1. Splice connectors for conductors No. 10 AWG and smaller gauge solid conductors shall be insulated pressure twist-on nut type.

2. Splice connectors for No. 8 AWG and larger gauge conductors shall be split bolt or compression type for making parallel or butt splices. Provide companion preformed plastic insulating covers or tape equivalent to conductor insulation.

3. Provide solderless terminal lugs for stranded and multiple solid conductors at connection to terminals or use UL listed crimp tool compression style lugs.

4. Control conductor connection terminations shall be either spade lug or pressure type.

5. Underground cable or wire splices in cabinets or boxes shall be made with submersible waterproof heat shrink type splices.

2.6 BOXES

A. General

1. Boxes on conduit raceways shall be made of the same material as the conduit except on PVC conduit use PVC coated steel, fiberglass, stainless steel, or protective coated cast metal alloy.

B. Outlet, Junction and Pull Boxes

1. Outlet, junction and pull boxes for use in dry areas shall be one piece galvanized sheet steel knock-out type a minimum size of four inches square or octagonal and 1-1/2 inches deep. Provide appropriate and compatible cover for each box.

2. Boxes for use in damp and wet areas shall meet requirements of NEMA 4, be epoxy coated cast aluminum or galvanized cast iron with threaded external hubs for conduit

entrance a minimum size as stated for boxes in dry areas. Boxes shall have gasketed cover plates and have stainless steel hardware.

3. Boxes for use in corrosive areas shall meet requirements of NEMA 4X, stainless steel with threaded external hubs and extended ears for conduit entrance a minimum size as stated for boxes in dry areas. Boxes shall have gasketed cover plates and stainless steel hardware.

2.7 WIRING DEVICES

A. Switches

1. Wall switches shall be rated a minimum 20 amperes.

B. Receptacles

1. General utility convenience receptacles shall be rated a minimum of 20 amperes, industrial grade. Provide GFCI receptacles where indicated.
2. Provide special purpose receptacles of the type, rating and number of poles as shown on the Drawings.

C. Device Plates

1. Device plates for outlets shall be one piece suited for the device installed. Plates on unfinished walls shall be zinc-coated sheet steel or cast metal with rounded edges. Screws shall be countersunk heads with color and finish to match plate. Weatherproof plates shall have plug enclosing hinged covers.

2.8 TERMINAL CABINETS

A. Terminal cabinets shall be of the type enclosure as shown on Drawings. Cabinets shall be complete with a continuous piano hinged door(s), back panel to mount terminal blocks, and terminal blocks. Sheet steel cabinets shall be primed and finished coated inside and outside with the manufacturer's standard finish. Stainless steel and non-metallic cabinets shall not be painted. Nema 4 and 4X cabinets shall be provided with quick release latches. Furnish sufficient terminals to accommodate all active and spare conductor terminations shown on the Drawings plus 30 percent extra terminations, unless otherwise noted. All terminals and back panels shall be mounted from the front of the cabinet. Mounting where a fastener extends through the back of the cabinet is acceptable only for Nema 1 cabinets.

1. Panels for dry areas shall meet requirements of NEMA-1 and be galvanized minimum 16 gauge steel, surface or flush mounted.

2. Panels for damp or wet or corrosive areas shall meet requirements of NEMA-4X and be minimum 16 gauge stainless steel with stainless steel accessories and hardware.

3. Terminal strips shall be standoff mounted and be the channel mounting type with marking strips.

2.9 ENCLOSED CIRCUIT BREAKERS

A. Circuit breakers for enclosed application shall meet requirements of UL489 with interrupting capacity of at least 10 KAIC or higher if noted and shall be UL listed as suitable for the type of conductor provided. Circuit breakers shall be molded case, quick-make, quick-break, thermal magnetic trip type, trip indicating and bolted in type. Provide visible trip rating on each breaker. Single pole breakers shall be full module size. Two and multiple pole circuits shall be of the common trip type having a single operating handle. Single pole circuit breakers with handle ties for multiple pole breakers are not accepted.

B. Circuit breakers for service disconnect shall be the same as 1. above except suitable for service entrance.

2.10 MOTOR CONTROLS

A. Where not otherwise indicated, motor starters for individual items of equipment shall be furnished by the equipment supplier and shall conform to the necessary provisions of the NEC.

B. Motor Protective Switches, Hand Starters: Shall be manual type with overload relay for each phase, and poles as required.

C. Magnetic Starters: Shall be across-the-line, magnetic type unless indicated otherwise. Overload relay for each phase and with poles as required. Where combination magnetic starter is called for, provide circuit breaker starter unless noted.

D. Overload Relays: Unless indicated otherwise all magnetic starters shall be equipped with solid state electronic overload relays. Relays shall be adjustable for trip current, shall be ambient and harmonic insensitive, and shall provide phase loss and low voltage protection.

E. Pushbutton Stations: Heavy duty with maintained contact, START-STOP buttons and amber indicating light unless otherwise indicated.

F. Enclosures: Surface mounted, NEMA 4X, unless otherwise indicated.

G. Manufacturers: Square-D, Siemens, or Cutler-Hammer. All controllers and accessories to

be by the same manufacturer.

H. Combination starter shall be of size, enclosure, and type as indicated on the plans and shall have:

1. Operator and operator arm permanently attached to handle of breaker and with positive indication and control of position with door either open or closed.
2. Tamperproof door latch with coin-proof slot in door handle latch.
3. Positive door seal.
4. Double safety interlocking of operator and door handle to prevent opening door with breaker in the "ON" position. Inter-lock by-pass shall be provided to give access to authorized personnel.
5. Provisions for padlocking of operator to lock disconnect in the "OFF" position. Door handle shall also be padlockable.

2.11 DISCONNECT SWITCHES

A. Disconnect safety switches shall be fusible or non-fusible with ampere rating, rating, number of poles and enclosure type as shown on the Drawings. All switches shall be heavy duty type. Mechanisms shall have quick-make, quick-break operating handles with provisions for padlocking in the OFF position, interlock to prevent unauthorized opening of the cover when the switch is in the ON position and to prevent closing the switch mechanism with the cover open.

B. Field coordinate with mechanical contractor for disconnect switches provided with specified equipment. Locate and fuse disconnect switches as per manufacturer's requirements.

2.12 GROUNDING

A. Bond all new work to the existing grounding electrode and bonding systems. Provide new rods and conductors as required for new work in accordance with NEC Article 250.

B. Ground clamps shall be copper alloy multi-bolt type, saddle clamp or compression type assembled with bronze bolts, nuts and washers.

2.13 LIGHTING FIXTURES

A. General: Contractor shall furnish and install lighting fixtures as indicated on the electrical plans.

B. Fixture type is shown at each fixture on the electrical drawings, and the contractor shall be responsible for the complete installation of all fixtures. Architectural drawings shall be consulted for necessary details of exact mounting methods and locations, where required. All standard fixtures, as specified by catalog number on the drawings, shall be approved by the Underwriters' Laboratories, Inc. and shall have the inspection label attached thereto. Attaching of UL labels after delivery of fixtures will not be acceptable. Louvers which are removable for relamping but not hinged shall be equipped with No.16 jack chain securely fastened near end of the louver.

C. The contractor shall take whatever steps are necessary to remedy in a satisfactory manner any lighting fixture or installation deficiency which may develop after the installation of lighting fixtures.

D. Supports:

1. Individually mounted fluorescent fixtures shall be with two single set, hangers. Fixtures mounted in continuous rows shall have one stem hanger per fixture plus one. The maximum spacing of hangers supporting a continuous row of four foot fixtures shall not exceed the nominal length of such fixtures. Coordinate location of hangers with structural features of exposed ceiling whenever possible, for uniform appearance.

2. Conduit stems shall be rigid steel conduit with threaded fittings. Conduit stems, rods, and strong back supports for lighting fixtures shall be painted with one coat of primer and two coats of exterior enamel, color as selected by the Engineer.

3. Outlet boxes used for supporting fluorescent fixtures shall be supported by one of the following methods.

    (a) By any rigid bar hanger such as 1-5/8" framing channels, ¾" rigid steel conduit, or equal which will support the fixture.

4. Supports for fixtures other than by outlet box shall be by using preset concrete inserts, or caulking anchors with machine threads using one 1/4" - 20 screw for single support or two No. 10-24 screws where double supports are required.

5. Fluorescent fixtures 48" or longer shall not be supported from outlet box ears. A suitable fixture stud shall be provided in each outlet box for supporting these fixtures. All fixtures weighing more than 50 pounds shall be supported independently of the outlet box. Al surface mounting fixtures more than 18" wide, in addition to the supporting from the outlet box, shall be supported at, or near, each corner.

6. Continuous runs of fixtures shall be installed straight and true and shall be equipped with all necessary parts such as joining straps, couplings, nipples, etc. for complete and workable units. All recessed fixtures shall be installed using supporting brackets, ground, plaster rings, etc, as recommended by the fixture manufacturer. All supports for fixtures shall be furnished. Lengths shall be adjusted to meet conditions.

E. Ballasts:

1. All fluorescent fixtures shall be equipped with ballasts suitable for cold weather and the line voltage for type, size, and number of lamps required by the fixture, and the fixture shall be so wired. All ballasts shall be high power factor type, and shall be listed by UL. All ballasts shall be energy saving type for use with energy saving lamps.

F. Lamps:
The contractor shall furnish and install all lamps in all fixtures supplied in the electrical contract of size shown on the drawings and as specified herein. All lamps shall be G.E., Phillips, or Sylvania. Unless otherwise specified in subsequent sections, all fluorescent lamps shall be cool white. The contractor shall furnish one complete set of replacement lamps.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install electrical equipment and material of the size, type and general routing as shown on the Drawings or on approved Contractor's Drawings.

B. Install metallic raceway, fittings, boxes and cabinets free from direct contact with reinforcing steel.

C. Provide fasteners, anchor bolts, anchorage items and supports as required to insure proper and rigid alignment. Attach equipment with fasteners sized according to size and weight of equipment and thickness of supporting surface.

D. Where aluminum is placed in contact with dissimilar metal or concrete, separate contact surfaces with gasket, non- absorptive tape or coating to prevent corrosion.

E. Make metallic conduit, raceways and cable trays electrically and mechanically continuous and ground as required. Conduits shall be continuous between outlets, boxes, cabinets and panels, and shall enter and be secured to each box.

F. Provide ground conductor in each conduit run.

G. Except where indicated otherwise not more than one 3-phase circuit or feeder shall be installed in a conduit run.

H. Repair or replace all damaged raceway and fittings. All scratches in PVC coated RGS shall be touched up and all threads shall be coated after assembly. If raceways cannot be adequately repaired in the judgment of the Engineer, they shall be replaced. Any conduit threads showing corrosion or improper coating at the final inspection shall be re-coated and re-inspected.

I. Install sealing fittings on all raceway runs into the pump station wet wells.

3.2 CONDUIT RACEWAYS

A. General

1. Install conduits parallel or perpendicular to building floors, ceilings and walls, and to avoid interference with other work. Cut conduits square and deburr cuts to the same degree as conduit manufacturer. Fasten conduit securely to outlets, junction, pull and terminal boxes. Provide caps and seals to prevent entrance of foreign material and moisture during installation and before wire pulling.

2. Keep conduit at least six inches away from high temperature piping, ducts, flues and surfaces. For mounting on concrete and masonry surfaces provide a minimum of 1/4 inch standoff support. Support and fasten conduit to building structural members using pipe straps, wall brackets, hangers or ceiling trapeze spaced in accordance with electrical codes. Support conduit at least every eight feet and within three feet of every box, panel and enclosure.

3. When two or more exposed conduits are in the same general routing provide parallel installation with symmetrical bends and for three or more provide channel racks. Provide channel rack space for 25 percent additional conduits.

4. Make changes in direction with bends and fittings. Field-made bends and offsets shall be made with a hand bender or conduit-bending machine. Conduit runs shall have no more than the equivalent of three 90 degree bends within 75 feet between boxes or two 90 degree bends within 125 feet. Pull boxes shall be provided where shown, specified or wherever required to pull conductors and to meet the above requirement. Install expansion fitting when conduit crosses building structural expansion joint. Unless otherwise approved, conduits shall cross perpendicular to building structural expansion joints.

B. Use of Different Types of Conduit

Conduit Use Schedule

Area	Enclosure	Device	Conduit
a. Underground Vaults	NEMA-4X	W.P.	Sch 80 PVC
b. Outdoors	NEMA-4X	W.P.	GRS or IMC
c. Pump Vault (Wet Well) Note 4.	NEMA 7	None	PVC Coated RGS
d. Underground	Nema 4X	N/A	Sch 80 PVC
e. In Structural Concrete	Nema 4X	N/A	PVC

NOTE:

1. Minimum size conduit 3/4" with no more than one circuit except where indicated otherwise.
2. Minimum 1/4" spacing of walls.
3. All PVC stub-up's, couple to PVC fittings and boxes at finished grade.
4. Provide conduit sealing fittings for all runs into the pump vaults.

C. Earth Buried Conduits

1. For conduits buried in earth provide minimum 30 inches of cover and minimum of one foot clearance between other utility crossings and parallel runs. Maintain a grade of at least four inches per 100 feet either from one manhole or pull box to the next or from a high point between them. Drain conduits away from building, if not possible provide watertight seal at building. PVC conduits shall be encased in at least 3" of sand or stone sand on all sides. Provide a detectable warning tape above all underground duct runs. Tape shall carry a suitable warning label for the underground duct and shall be installed 12" below the ground surface. Conduits arranged in duct bank construction shall be separated by 2" of concrete and the conduit arrangement shall have 3" minimum of concrete encasement.

D. Conduit Penetrations

1. Concealed penetrations for conduits shall be made not more than 1/4 inch larger than the diameter of the conduit. Penetrations through walls, ceiling and floors other than concrete for exposed conduits shall be not more than 1/4 inch larger than the

diameter of the conduit and void around conduit filled with caulking compound and surface finished same as wall, ceiling or floor.

2. Where a conduit enters through a concrete roof or membrane waterproofed wall, floor or ceiling, provide a watertight sealing sleeve that can be tightened from one or both sides. If the sealing sleeve is not placed with the concrete, core drill proper size hole to provide a mechanically watertight installation.

3. Where a conduit enters through a concrete non-waterproofed wall, floor or ceiling, provide a galvanized steel sleeve, schedule 40, and fill the space between the conduit and sleeve with plastic expandable compound. If the sleeve is not placed with the concrete, drill hole not less than 1/2-inch nor more than one inch larger than sleeve, center sleeve and grout sleeve total depth of penetrated concrete with non-shrink grout, polyurethane or silicone sealant.

E. Conduit Damage Correction

1. Repair cuts, nicks and abrasions or replace damaged conduit as required. Provide Owner with non-defective material and workmanship.

3.3 BOXES

A. General

Each box shall be of the proper size for the number of conductors enclosed in the box, in accordance with the NEC for box fill and conductor de-rating requirements.

1. For boxes mounted on steel, concrete and masonry surfaces provide minimum 1/4-inch spacer to hold box away from surface.

2. Provide separate support for boxes and bolt units to building with expansion anchors, toggle bolts or appropriate screws. For lighting fixture outlet boxes provide supports adequate to support weight of fixture to be mounted on the box.

3. Remove debris including dust, dirt, wire clippings and insulation from interior of boxes. Boxes with open conduit holes are not permitted and shall be replaced at no cost to the Commission. Damaged boxes shall be repaired or replaced as directed.

5. Where boxes are shown on each side of a common wall do not mount back-to-back but offset horizontally minimum of six inches.

B. Outlet Boxes

1. Unless otherwise indicated, space all off wall or railing minimum 1/4".

2. Unless otherwise shown on the Drawings or specified, mounting heights measured from the finished grade to centerline of the outlet box shall be as follows:

   a. For switches four feet and in addition for lighting switches mount on strike side of door.
   b. Duplex convenience outlets 18 inches.
   c. For fixtures and equipment as shown on the Drawings.

C. Junction and Pull Boxes

1. Provide pull boxes where required to facilitate conductor installation and to limit conduit runs to less than 150 feet.
2. Install pull and junction boxes in accessible locations with working space in front of and around the installation. Boxes are not permitted in finished areas without approval of the Engineer.

D. Terminal Panels

1. Provide terminal panels where shown on the Drawings and in accessible locations with working space in front of and around the installation.

3.4 CONDUCTORS

A. Install conductors as shown on the Drawings in raceways with no splices between boxes. Install complete raceway system and clear debris and moisture before conductor installation.

B. Pull conductors using proper equipment without exceeding manufacturer's recommendation for maximum pulling tension. Protect conductor insulation jacket at all times from kinks, scrapes, punctures and other damage. Replace damaged conductors. Use lubricating compound to reduce pulling force as required. Lubricating compound shall be UL listed compatible with the conductor insulated jacket and with the raceway.

C. Support conductors in vertical risers with woven grips to prevent loading on conductor connectors.

D. In conduits entering buildings or from areas where temperature change may cause condensation or moisture, seal between conductors and conduit after conductors are in place.

E. When using color coding tape apply with overlapping turns for a minimum length of two

inches starting two inches back from the termination point.

F. Leave a minimum of six inches of free conductor at each connected outlet and a minimum of nine inches at unconnected outlets.

G. Seals: Wires or cables installed in conduits penetrating exterior walls in underground structures shall be sealed watertight at the cabinet or other point of termination with an expandable rubber cable sealing bushing such as O.Z. Gedney Style CSB. This is to prevent water entering the cabinet or other termination from inside the conduit.

H. Voltage Drop: Provide no more than 3% VD on branch circuits and feeders.

3.5 WIRE CONNECTIONS AND CONNECTING DEVICES

A. Connect circuit conductors of the same color to the same phase throughout the installation.

3.6 WIRING DEVICES

A. Switches and receptacles shall be installed in accessible locations and so the long dimension is vertical.

B. Provide a bonding jumper between the grounded box and the switch or receptacle ground terminal.

3.7 CABINETS AND ENCLOSURES

A. Mount cabinets and enclosures so there is a minimum of 1-1/2 inch air space all around.

B. Arrange conductors in cabinets, panels and enclosures in a neat arrangement, cut to proper length and with surplus conductor removed.

C. Identify each circuit in the enclosure.

D. Provide terminals and connectors for the type of material being used.

3.8 GROUNDING

A. Unless otherwise specified, ground all exposed non-current carrying metallic parts of electrical equipment, raceway systems, and the neutral of all wiring systems in accordance with the NEC and other applicable codes.

B. Bond the grounding conductors to metallic enclosures at each end and to all intermediate metallic enclosures. Where equipment contains a ground bus, extend and connect grounding conductors to that bus. Run ground conductors inside conduits enclosing the power conductors.

C. Make connections of grounding conductors to circuits 20 amps or above by a solderless terminal and a 5/16 inch minimum bolt tapped to the motor frame or equipment housing. Ground connections to smaller equipment may be made by fastening the terminal to a connection box. Connect junction boxes to the equipment grounding system with grounding clips mounted directly on the box or with 3/8-inch machine screws. Remove all paint, dirt or other surface coverings at grounding conductor connection points so that good metal to metal contact is made.

3.9 CONCRETE BASES

A. Construction concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 4000-psi, 28-day compressive-strength concrete and grade 60 reinforcement.

B. Coordinate all concrete requirements with Division 01.

3.10 CUTTING AND PATCHING

A. Cut, channel, chase and drill floors, walls, partitions, ceilings and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

A. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.11 FIELD QUALITY CONTROL

A. Test all circuits for shorts, connections and balance loads within 6% if each phase.

B. Test ground for continuity and resistance. Grounding neutrals for a distribution system 600 volts and below shall not exceed ten ohms.

C. Test each individual power circuit at the panel with the power equipment connected for proper operation.

D. Correct defects and failures in a manner acceptable to the Engineer.

END OF SECTION